

SEASONAL REDISTRIBUTION OF WATER IN THE SURFICIAL MARTIAN REGOLITH: RESULTS OF THE HEND DATA ANALYSIS. R.O.Kuzmin¹, E.V.Zabalueva¹, I.G.Mitrofanov², M.L.Litvak², A.V.Parshukov², V.Yu.Grin'kov², W.Boynton³, R.S.Saunders⁴. *1 - Vernadsky Institute of Geochemistry and Analytical Chemistry, RAS, Moscow, 119991, Russia rok@geokhi.ru; 2 - Institute for Space Research, RAS, Moscow, 117997, Russia; 3 - University of Arizona, Tucson, AZ 85721, USA; 4 - NASA HQ, Washington, USA.*

Introduction: The global mapping of the neutrons emission from the Mars, conducted recently by HEND instrument (Mars Odyssey), has shown that the surface layer (1-2 m) on the high latitudes of the planet (up to 50°) is very reached by water ice with abundance more 50% by mass [1,2,3]. It was also shown that water ice distribution in surficial layer of the northern and the southern sub-polar regions is notably different [4]. Until today the existing HEND data already covers the period more then one the Martian year. This let to study the seasonal effects of volatiles redistribution associated with processes of sublimation and condensation of the seasonal polar caps and water exchange between the surface regolith and atmosphere. The goal of our work was to analyze the dynamic of the globally mapped neutrons flux as key to understanding of the seasonal redistribution of the water ice in the surface layer. For this we analyzed the globally mapped flux of the neutrons with different energy and corresponding effective layer of their emission.

Observations: Mapping of the fast neutrons flux has shown strong seasonal variations of the flux and their anomalous regime during Northern winter (fig.1).

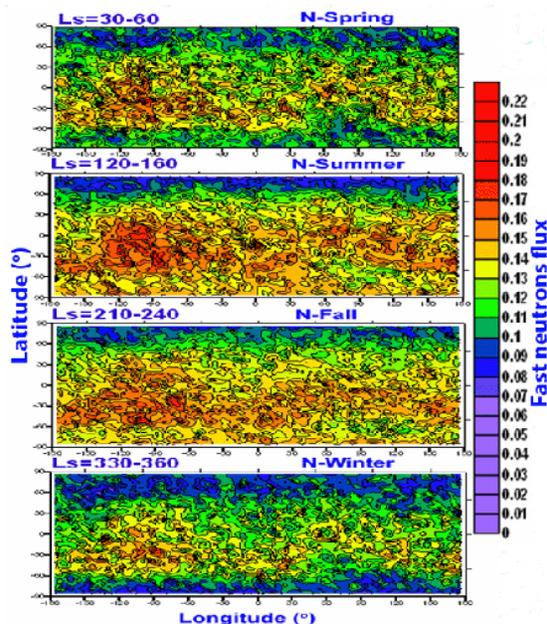


Figure 1. Global maps of the seasonal variations of the fast neutron flux on Mars, measured by HEND instrument.

The global mapping of the neutrons emission from Mars has been realized at different energy ranges of

the neutrons: by two ranges for both epithermal (100eV-10keV and 10keV-1MeV) and fast neutrons (1MeV-2.5MeV and 2.5MeV-10MeV). The corresponding effective layers from where the neutrons emitted are equal to ~1.5-2 m, ~1m, 20-30 cm and ~10 cm respectively for indicated energy ranges. We analyzed the data as function of areocentric longitudes (Ls) and the latitude. The data were averaged in 10° range of latitude and in 15° range of Ls and have been normalized to the neutrons flux emitted from Solis Planum as the driest region on Mars (fig.2,3).

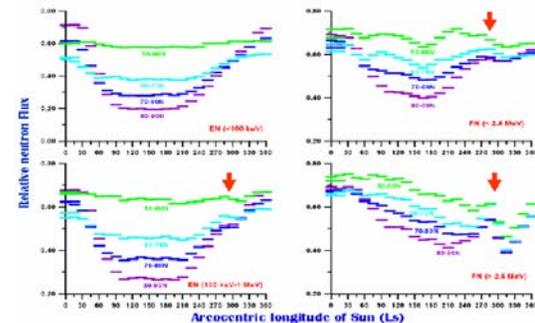


Figure 2. Dynamics of the neutrons flux in Northern hemisphere versus Ls and latitude. Red arrow indicates the neutron flux reduction during winter (Ls=270°-330°).

Analyses of the data has shown that the dynamics of the most low-energy epithermal neutrons flux (100eV-10keV with effective layer 1.5-2 m) on the high latitudes of both sub-polar regions of Mars is consistent well with sequence of sublimation and condensation processes in the seasonal polar caps (fig.3a). The flux of the epithermal neutrons consequently increases during condensation of the CO₂ in the winter and approach the most minimal value at completely sublimated seasonal caps. Other situation is found for the dynamic of higher energy epithermal and fast neutrons flux (with thinner effective layers of the neutrons emission): in the northern hemisphere it remarkably different than in southern hemisphere. As it well seen from fig.3b,c,d, two distinctive “hollows” of neutrons flux reduction have been appeared in the northern hemisphere during northern summer at Ls=130°-170° and in first half of northern winter at Ls=270°-330°, being extended from high to low latitudes. At that, later the “hollow” (Ls=270°-330°) is characterized by much stronger reduction of the region up to low latitudes in the southern hemisphere.

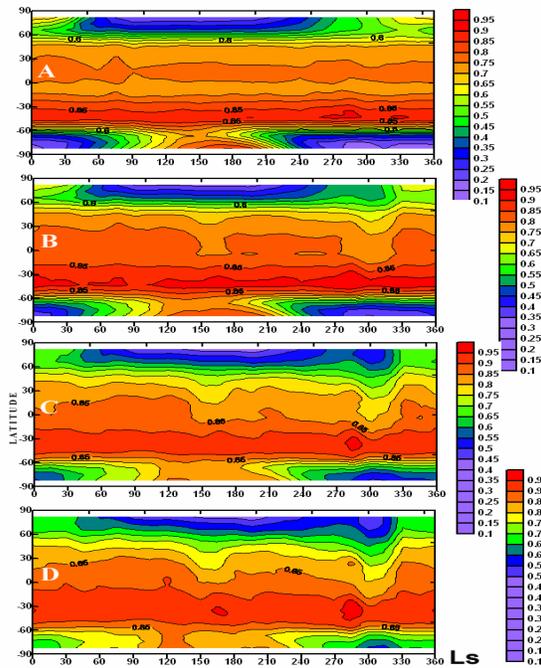


Figure 3. The maps of the normalized neutrons flux dynamic during one the Martian year for different neutrons energy ranges. For epithermal neutrons (100eV-10keV (a) and 10 keV-1MeV (b) and fast neutrons (1Mev-2.5Me (c) and 2.5MeV-10MeV(d)).

The first “hollow” is related with periods of the northern summer, while the second one – with of the southern middle summer. In both case the residual polar caps serve as main source of the water in the Martian atmosphere. It is remarkable that during period with $L_s=270^\circ-330^\circ$, when the seasonal cover of CO_2 -ice has been formed on the latitudes $>60^\circ N$, the noticeable decreasing of the neutron flux is observing in both the sub-polar and middle-latitude regions. Observing reduction of the neutrons flux in the northern sub-polar region represents the “sagging” on the background of monotonic increasing of the neutrons flux in the autumn/winter period ($L_s 200^\circ-360^\circ$) associated with growing of seasonal cover from CO_2 -ice. At that, there is the next distinct tendency: the higher energy of the neutron (or thinner the effective layer), the much stronger reduction of the neutrons flux is observing (see fig.1,3,4). As it seen from fig.4, the percentage of the neutrons flux reduction (in each energy range) increases very slowly in the latitude range $90^\circ N-70^\circ N$ and much intensively in $70^\circ N-60^\circ N$, being constantly higher at most shallower effective layer.

Discussion: Because the value of the neutrons flux are sensitive to water abundance in the surface layer [5], the observing effect of the neutrons flux reduction may to be considered as indicator of some temporal increasing of the water content in the surface layer in the season of the year(in form of water ice or clathrate

$CO_2 \cdot 6H_2O$). It is known [5] that even increasing of the water abundance in the surface material on 1% of mass may result to reduction of the emitted fast neutrons approximately on 10%. The maximum reduction value of the fast neutrons flux, observing in the season,

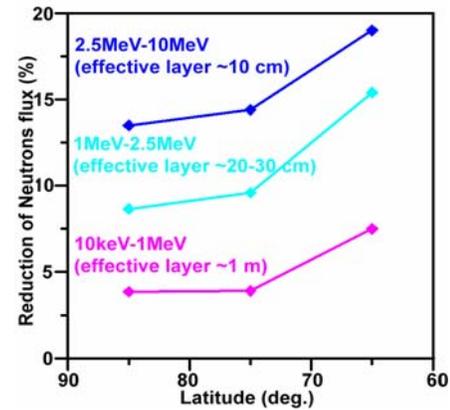


Figure 4. Reduction of the neutrons flux value (in %) in the northern sub-polar region during period $L_s = 270^\circ-330^\circ$ for different energy ranges.

equal to $\sim 20\%$. As reasonable water source for observing increasing of the water abundance in the surface layer most likely serves the meridional water vapor mass transfer from the sublimated residual southern polar cap to north via the Hadley cell circulation. Following to our approximate calculations, the precipitation of H_2O -ice (frost) on the latitudes $>60^\circ$ (due to water vapor transport from southern hemisphere) may to be equal to 1-10 pr. mm during the period $L_s=270^\circ-330^\circ$. We suggest that the visible reduction of the neutrons flux outside of the seasonal cover of the CO_2 -ice (up to the equatorial regions), may to be associated with both condensation of the H_2O frost on the surface and hydration of a salts minerals (mostly sulfates and chlorides) contained in the Martian soil. The smaller neutrons flux reduction, observing in the period $L_s=130^\circ-170^\circ$, is rather associated with hydration process in the surface regolith due to high atmospheric humidity in the period.

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